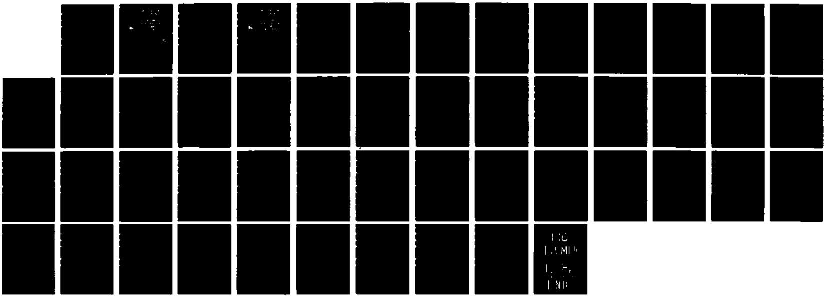
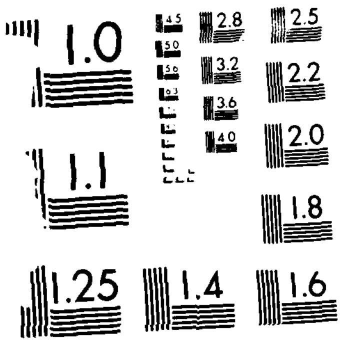
AD-A165 499 COMPUTER BASED WAVE REFRACTION ANALYSIS FOR THE AIR COMBAT MANEUVERING RA..(U) NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON DC CHESAPEAKE.. OCT 76 1/1

UNCLASSIFIED CHES/NAVFAC-FPO-1-77(4) F/G 8/3 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

FPO-

FPO-1-77(4)

FPO
7704

AD-A165 499

COMPUTER BASED WAVE REFRACTION ANALYSIS FOR THE AIR COMBAT MANEUVERING RANGE (ACMR) CONSTRUCTION PROJECT

OCEAN ENGINEERING
AND CONSTRUCTION PROJECT OFFICE
CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D.C. 20374

OCTOBER 1976

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION
Unclassified

1b. RESTRICTIVE MARKINGS

2a. SECURITY CLASSIFICATION AUTHORITY

3. DISTRIBUTION AVAILABILITY OF REP.
Approved for public release;
distribution is unlimited

2b. DECLASSIFICATION/DOWNGRADING SCHEDULE

4. PERFORMING ORGANIZATION REPORT NUMBER
FPO 7704

5. MONITORING ORGANIZATION REPORT #

6a. NAME OF PERFORM. ORG.
Ocean Engineering
& Construction
Project Office
CHESNAVFACENGCOM

6b. OFFICE SYM

7a. NAME OF MONITORING ORGANIZATION

6c. ADDRESS (City, State, and Zip Code)
BLDG. 212, Washington Navy Yard
Washington, D.C. 20374-2121

7b. ADDRESS (City, State, and Zip)

8a. NAME OF FUNDING ORG.

8b. OFFICE SYM

9. PROCUREMENT INSTRUMENT INDENT #

8c. ADDRESS (City, State & Zip)

10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT #	PROJECT #	TASK #	WORK UNIT ACCESS #

11. TITLE (Including Security Classification)
Computer Based Wave Refraction Analysis for the Air Combat Maneuvering Range (ACMR) Construction Project

12. PERSONAL AUTHOR(S)

13a. TYPE OF REPORT

13b. TIME COVERED
FROM TO

14. DATE OF REP. (YYMMDD)
76-10

15. PAGES
47

16. SUPPLEMENTARY NOTATION

17. COSATI CODES

FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (Continue on reverse if nec.)
Air Combat Maneuvering Range, Towers, Ocean construction

19. ABSTRACT (Continue on reverse if necessary & identify by block number)
This report presents the results of a computer-based wave refraction analysis which was executed in conjunction with the design of the four marine structures of the U.S. Navy East Coast Air Combat Maneuvering Range, located offshore at Kitty Hawk, North Carolina.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT
SAME AS RPT.

21. ABSTRACT SECURITY CLASSIFICATION

22a. NAME OF RESPONSIBLE INDIVIDUAL
Jacqueline B. Riley

22b. TELEPHONE
202-433-3881

22c. OFFICE SYMBOL

DD FORM 1473, 84MAR

SECURITY CLASSIFICATION OF THIS PAGE

COMPUTER BASED WAVE REFRACTION ANALYSIS FOR THE AIR COMBAT MANEUVERING RANGE (ACMR) CONSTRUCTION PROJECT

FPO-1-77(4)

OCEAN ENGINEERING
AND CONSTRUCTION PROJECT OFFICE
CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D.C. 20374

OCTOBER 1976

PREFACE

The analysis, which provided a foundation for this report, was conducted by Dr. Yung Y. Chao, Consulting Oceanographer, 100 Meadow Terrace, South Plainfield, New Jersey 07080. Report development was accomplished by Mr. Melvin L. Bunnell of EG&G Washington Analytical Services Center, Inc., Rockville, Maryland.

This report serves to complement the environmental design criteria prepared for the Air Combat Manuevering Range (ACMR) project. Data and determinations presented herein are those not normally provided in a climatologically-based environmental report.

A1

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Cont'd)

LIST OF ILLUSTRATIONS (Cont'd)

LIST OF TABLES

1.0 INTRODUCTION

This report presents the results of a computer-based wave refraction analysis which was executed in conjunction with the design of the four marine structures of the U.S. Navy East Coast Air Combat Maneuvering Range, located offshore at Kitty Hawk, North Carolina. Figure 1-1 shows the general layout of the towers.

The structures will consist of a three-pile jacket (template) with equilaterally-spaced legs through which steel piles are driven into the seabed. Jackets are then secured to the piling by welding shim plates in the annulus between the jacket leg and piling at the top of the jacket legs. Following this, a superstructure consisting of an equipment deck and an upper deck is attached to the piling above the top of the jacket.

Orientation of the structures will be such that the side of the platform with solar panels will face due south. This places the side of the structure with the proposed boat landing to the northeast. Site locations of the structures are presented in Figure 1-2 and will be as follows:

Site #	Latitude (N)	Longitude (W)	Water Depth (MLW) (ft)	Distance to Shore (NM)
1	35° 56.99'	75° 16.00'	81	15.80
2	36° 13.60'	75° 14.99'	93	24.00
3	36° 03.87'	74° 59.00'	105	31.70
4	35° 47.19'	75° 05.71'	105	20.00

The goal of the wave refraction analysis was to determine if the topographic refraction effect on deep water waves propagating toward shore would produce anomalously high local wave conditions at the proposed tower construction sites.

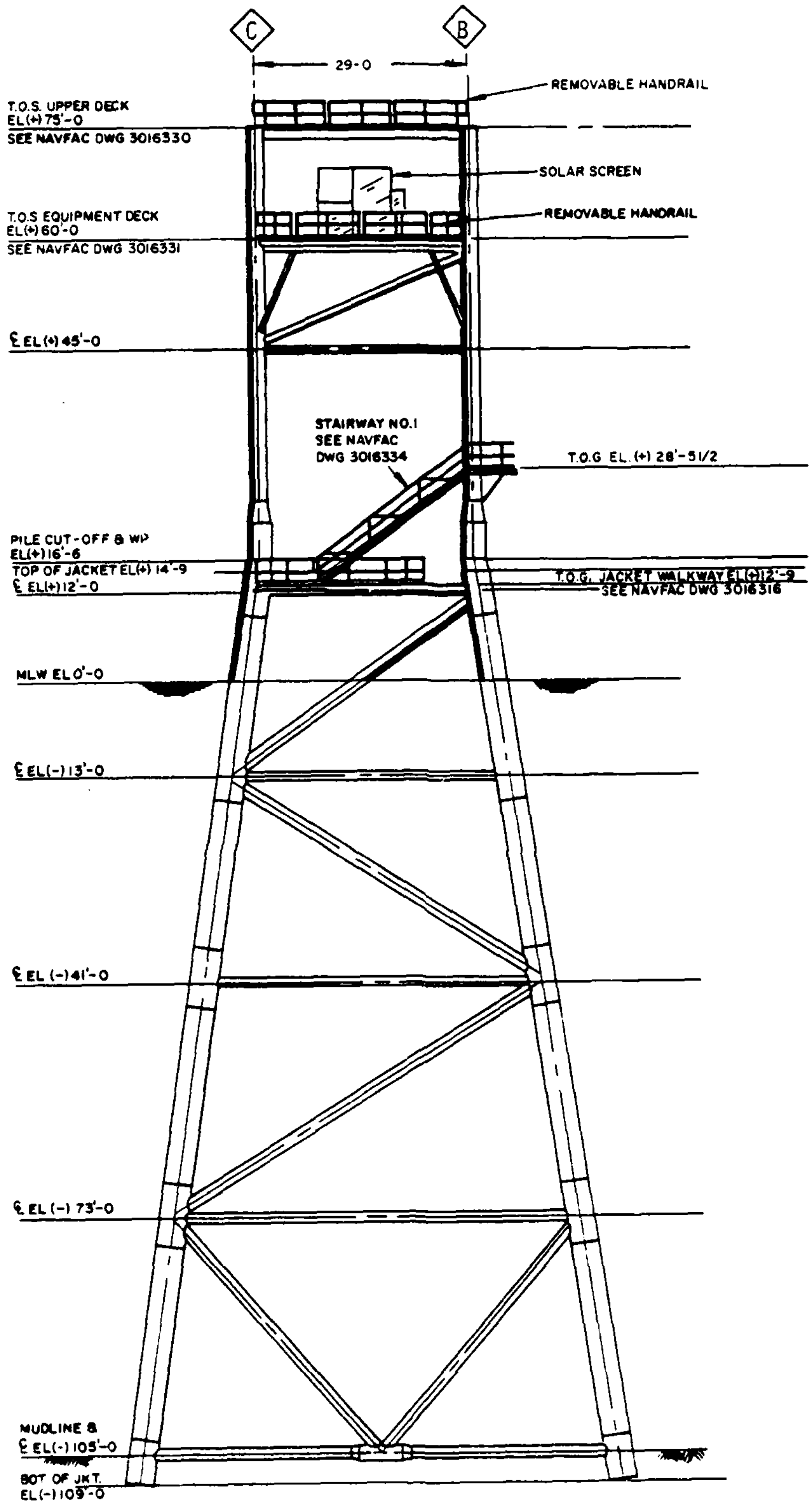


Figure 1-1. General Layout of Marine Structures

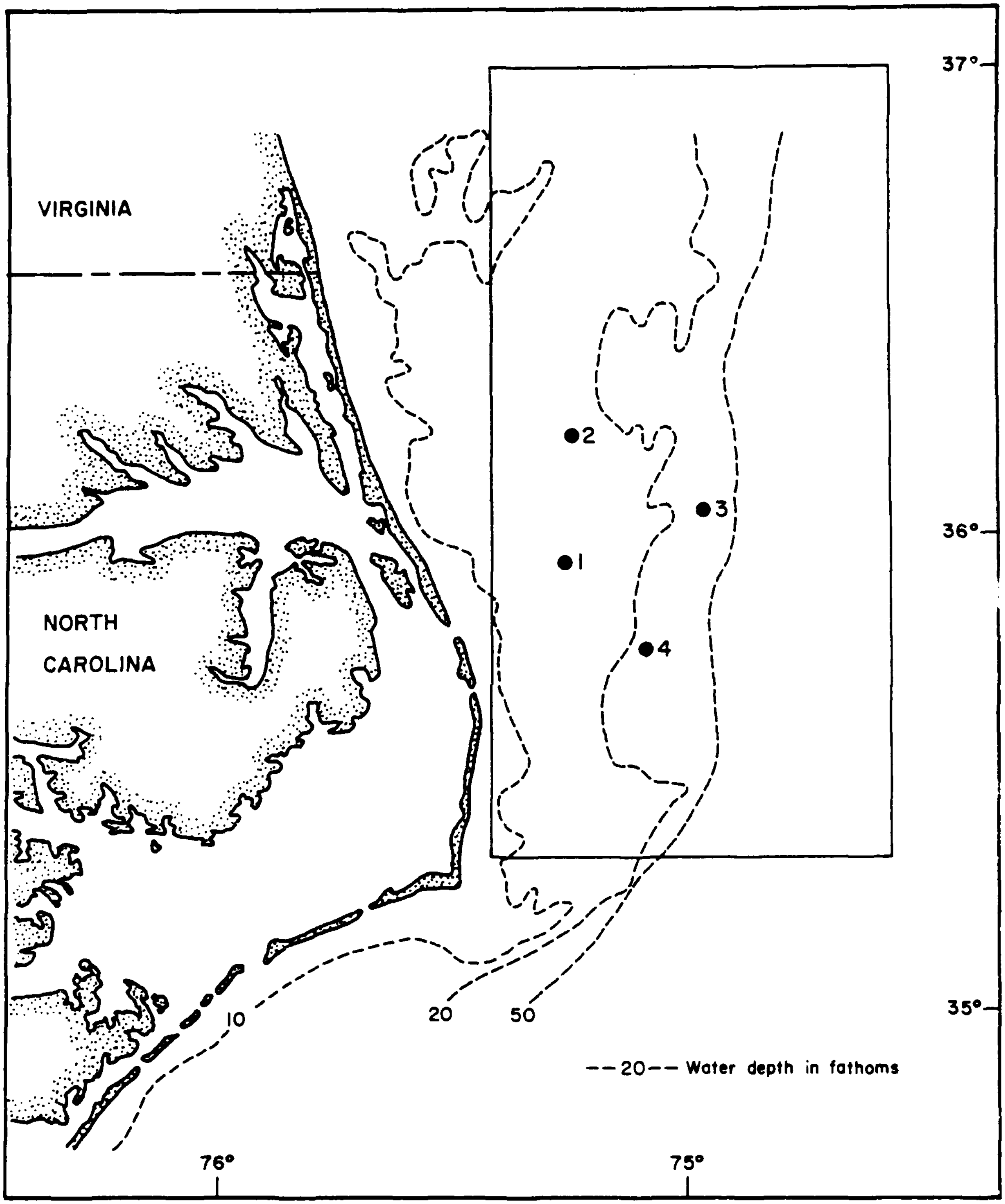


Figure 1-2. Location of the Marine Structures

(Boxed area encloses numerical grid used for the computer analysis, see Figure 3-1)

2.0 ANALYSIS CONSTRAINTS

The wave periods considered in this analysis are 10.0, 11.5, and 13.0 seconds. It was assumed that the waves likely to have the greatest impact on structure survival will fall into this range of periods. Deep water wave directions (9) considered for each wave period of concern are the following azimuths (defined as forward direction of wave propagation measured clockwise from north): 210°, 225°, 240°, 255°, 270°, 285°, 300°, 315°, and 330°. Thus, a total of 27 deep water wave conditions were considered in the analysis.

3.0 DIGITIZED DEPTH FIELD WITH GRID COORDINATES

To proceed with the wave refraction analysis, it was necessary to produce a digitized depth field with grid coordinates. The depth grid for this analysis was based on the bathymetric chart of the region prepared by V. Goldsmith and C. M. Sutton of the Department of Geological Oceanography, Virginia Institute of Marine Science. Included in this "gridded" depth field was the area bounded by latitude 35° 20.5'N to 37° 00.0'N and longitude 74° 35.0'W to 75° 24.5'W (see Figure 1-2). The grid interval is 0.5 minute in angular distance (both latitude and longitude), whereas the origin of the grid coordinates (1,1) corresponds to 35° 20.5'N and 75° 24.5'W. A right-hand coordinate system, positive toward east and north, was established which uses 100 by 200 grid points. Figure 3-1 presents the "gridded" depth field which is keyed to the geographical area of interest and site locations presented in Figure 1-2. Depth information was extracted from bathymetric chart at every third grid point. Depth data for the remaining grid points was obtained by employing an interpolation scheme. Thus, a smooth grid coordinate system for the depth field of the entire area of concern was obtained. The grid coordinates of construction sites #1, #2, #3 and #4 were (18,73.98), (20.20, 107.20), (52.00, 87.74) and (38.58, 54.38), or approximately (18,74), (20,107), (52,88) and (39,54), respectively. (Note: Logitudinal grid points are given first.)

Note that the "gridded" depths near or at the sites may differ slightly from recently collected soundings. This is due to the combined effect of depth interpolation to derive a smooth bathymetric field and the intrinsic inaccuracies of a bathymetric chart based on a variety of sounding sources. This discrepancy is of little consequence to the accuracy of the wave refraction analysis.

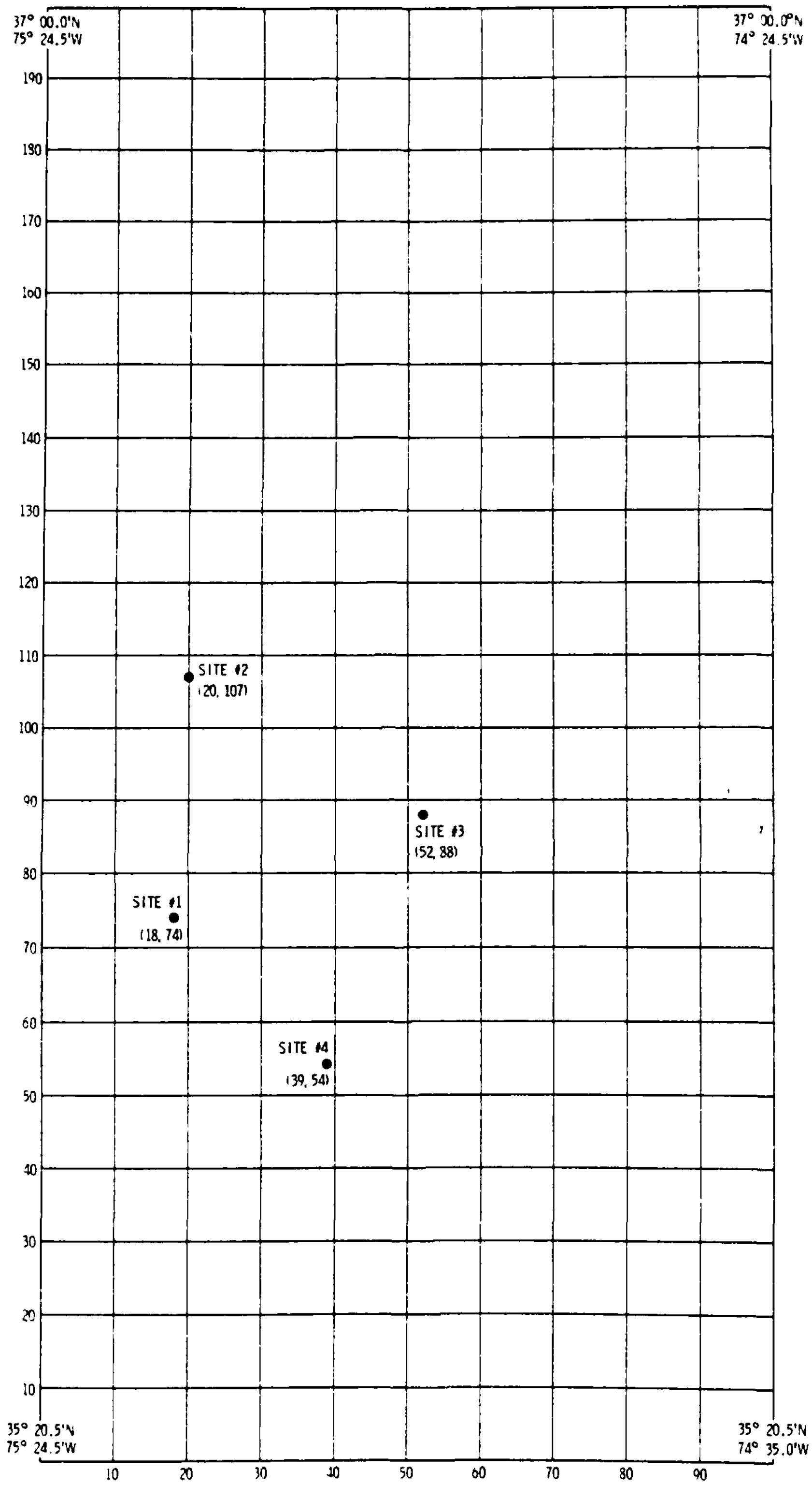


Figure 3-1. Map Showing Completed 100 by 200 Gridded Field

4.0 COMPUTER ANALYSIS

The numerical wave refraction analysis involved the execution of three major computer programs. The first program performs the calculations of all relevant parameters along an individual ray on the global coordinates for a given wave period, initial direction, and starting point. Following execution of the first program, a second computer run performs a correction of the refraction coefficient near and at a wave "caustic". A caustic point occurs where two adjacent rays, originally a differential distance apart, intersect. Consequently, the ray separation factor becomes zero at that point. According to the conventional geometric optic ray theory, which is employed in the first program, the refraction coefficient (reciprocal of the ray separation factor), and therefore the wave height, will become infinitely high at the caustic point and unrealistically high in the region of caustic influence. Thus, a second computer run, to correct for this error, has been executed.

The third computer program is used to present numerically the characteristics of refracted waves in terms of the wave height amplification factor and the directional change from the initial wave direction for each grid point. This is accomplished by employing a weighted average scheme according to the distances from the grid point of interest to the surrounding ray points.

5.0 RESULTS

The results of the computer analysis for the four sites of concern are given in Table 5-1. There are nine directions indicated with three periods for each direction; thus there will be twenty-seven cases for each site. For each case, an amplification factor and a refracted wave direction have been given. The refracted wave direction is the direction that a wave travels at the site after it experiences the effect of bottom topography. The amplification factor is based on a unit amplitude wave in deep water being propagated shoreward. For example, if the amplification factor at the site for a particular period is 0.7, it infers that the wave height is 70 percent of the deep water height.

Examining the refracted wave direction data for the four sites (Figures 5-1 through 5-4), it can be seen that waves moving shoreward from the northeast (propagating southwest 210° to 255°) will refract in a clockwise direction. Waves moving shoreward from the southeast (propagating northwest 285° to 330°) will refract in a counterclockwise direction. Eastward propagating (270°) waves show the smallest refraction effect. These results are in keeping with basic wave refraction theory.

The amplification factors associated with the four sites (Figures 5-5 and 5-6) show some variation. Sites #1 and #2, which are closer to shore, have significant amplification for a number of directions (see Figure 5-5). For site #1, amplification of deep water wave height takes place at:

a. 11.5 Sec period, 225°, factor = 1.1
b. 10.0 Sec period, 255°, factor = 1.2

Site #2, Figure 5-5, shows amplification at a 11.5-second period, with all directions greater than 290 degrees. The site #2 amplification factors have great significance when one considers the hurricane generated seas that attack the coast from the southeast.

TABLE 5-1. COMPUTER ANALYSIS RESULTS

SITE #		1		2		3		4	
REFRACTED WAVE DATA*		A	D	A	D	A	D	A	D
DEEP WATER WAVE DIRECTION	PERIOD (SEC)								
210 (30)	10.0	0.5	221	0.4	221	0.8	218	0.8	219
	11.5	0.7	227	0.6	233	0.8	223	0.8	224
	13.0	0.6	231	0.8	234	0.8	228	0.7	228
SW 225 (45)	10.0	0.9	231	1.0	234	0.9	230	0.9	231
	11.5	1.1	235	0.4	243	0.8	234	0.9	235
	13.0	0.6	241	0.4	246	0.8	237	0.9	239
240 (60)	10.0	0.9	244	0.8	245	0.9	243	0.9	244
	11.5	0.8	246	0.7	247	0.9	245	0.8	247
	13.0	0.8	248	0.8	248	0.9	248	0.8	249
255 (75)	10.0	1.2	260	0.9	256	0.9	256	0.9	257
	11.5	0.9	263	0.8	257	0.9	258	0.9	258
	13.0	0.8	265	0.8	257	0.9	259	0.9	259
W 270 (90)	10.0	0.9	272	0.9	270	0.9	270	0.9	270
	11.5	0.8	273	0.9	269	0.9	270	0.9	270
	13.0	0.8	273	0.9	268	0.9	271	0.9	270
285 (105)	10.0	0.8	284	0.9	283	0.9	285	0.9	284
	11.5	0.7	282	0.9	282	0.9	284	0.9	283
	13.0	0.7	281	0.9	281	0.9	284	0.9	281
300 (120)	10.0	0.9	298	1.0	297	0.9	299	0.9	299
	11.5	0.8	295	1.1	295	0.9	297	0.9	296
	13.0	0.9	294	1.0	294	0.9	295	0.9	293
NW 315 (135)	10.0	1.0	310	0.8	307	0.9	312	0.8	310
	11.5	0.8	305	1.3	303	0.9	309	0.7	307
	13.0	0.6	303	0.7	300	0.9	307	0.7	304
330 (150)	10.0	0.6	318	0.6	318	0.9	325	0.8	319
	11.5	0.9	315	1.1	311	0.8	321	0.5	315
	13.0	0.7	310	0.6	307	0.8	318	0.7	310

* LEGEND

A = Amplification factor

D = Refracted Wave direction (Azimuth, degrees)

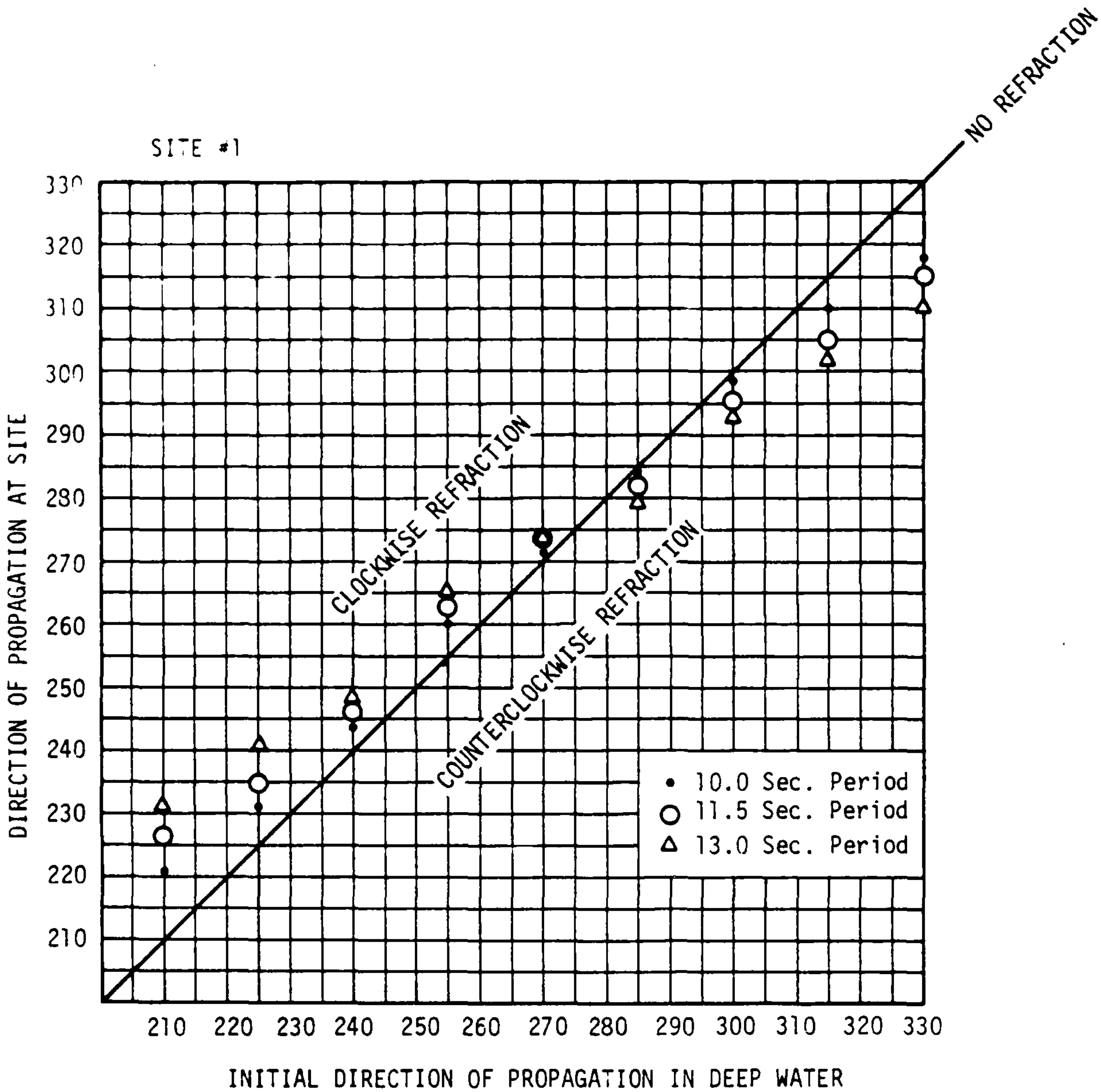


Figure 5-1. Refraction Correlation Diagram (Site #1)

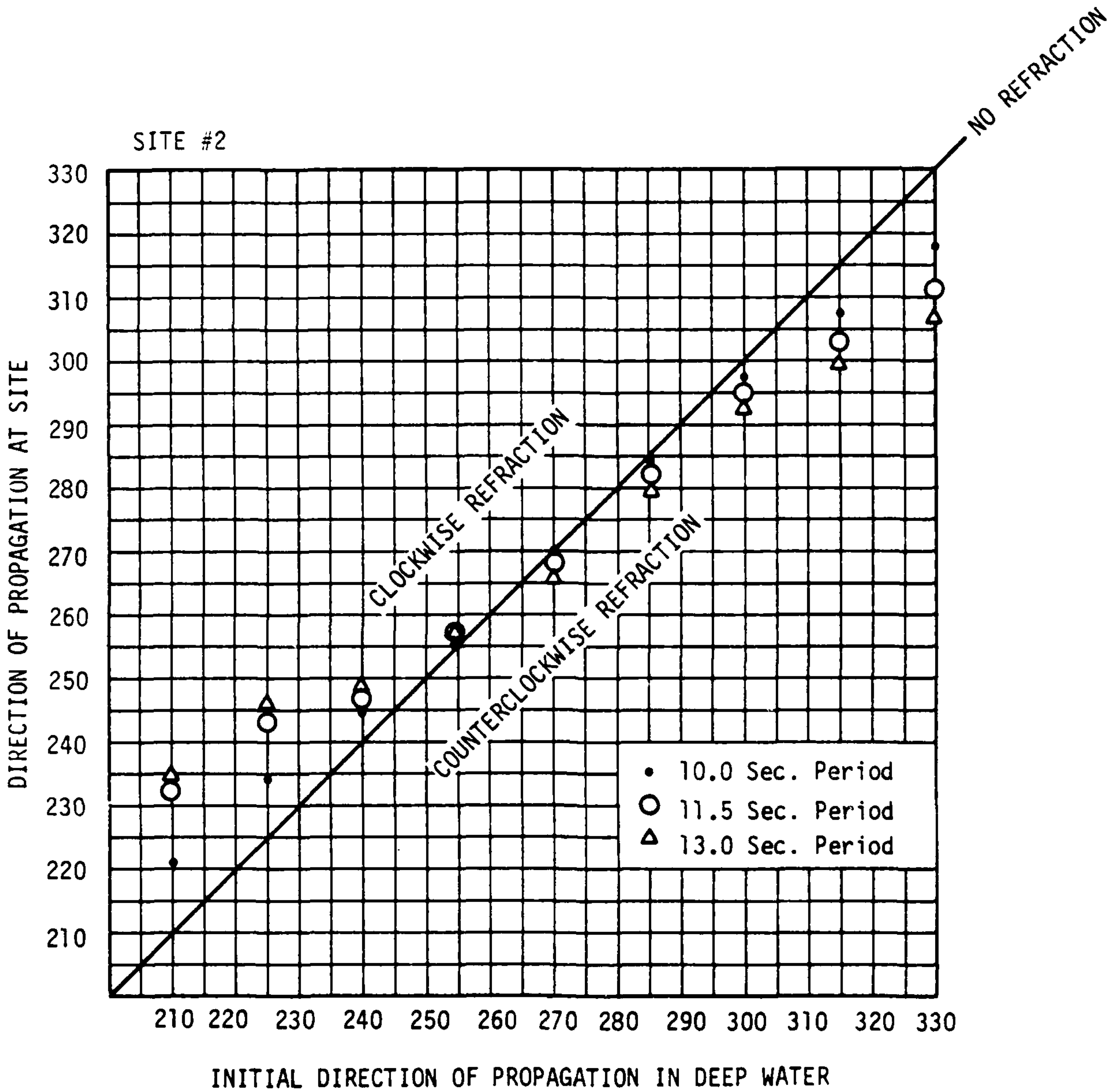


Figure 5-2. Refraction Correlation Diagram (Site #2)

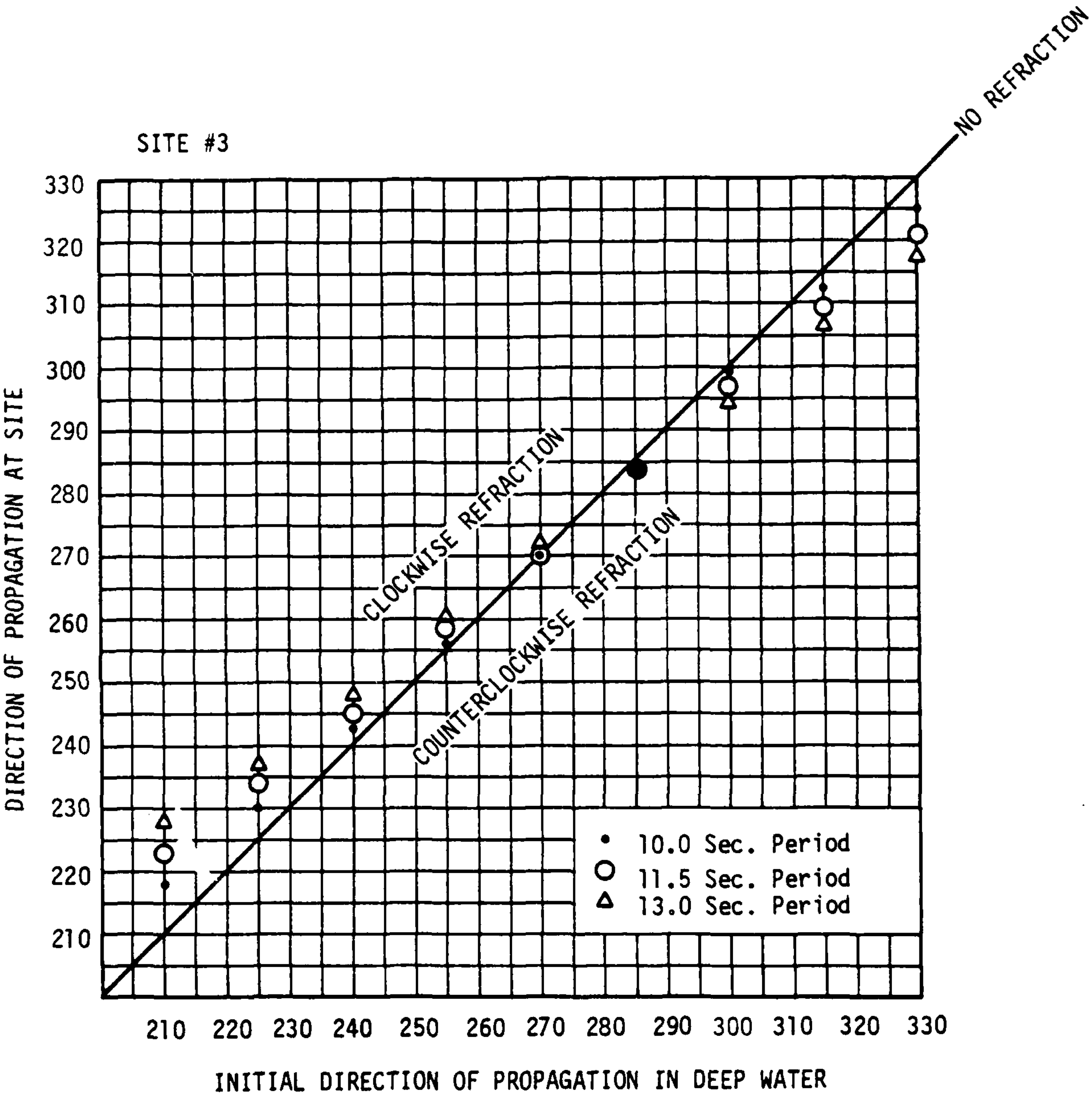


Figure 5-3. Refraction Correlation Diagram (Site #3)

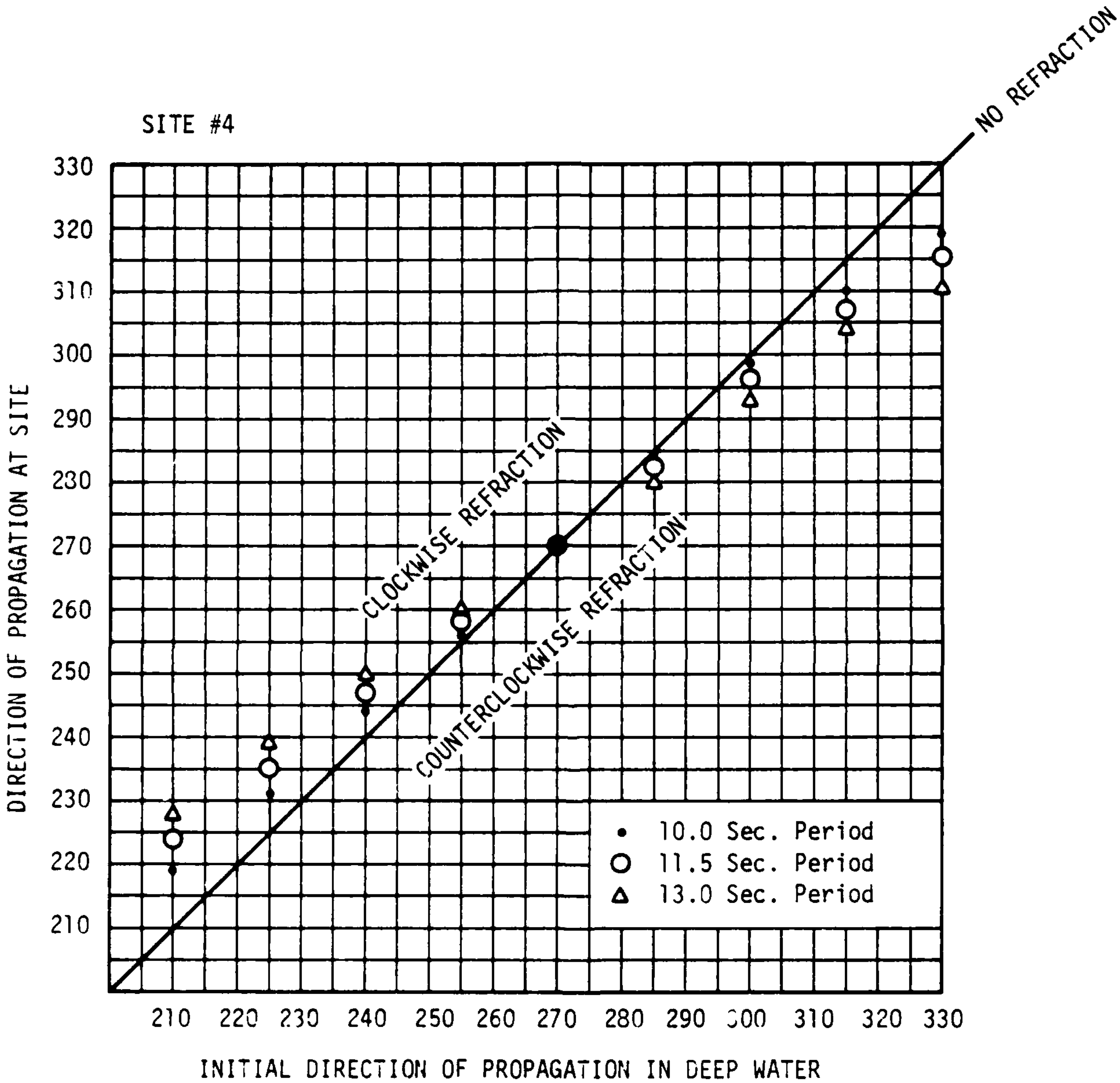


Figure 5-4. Refraction Correlation Diagram (Site #4)

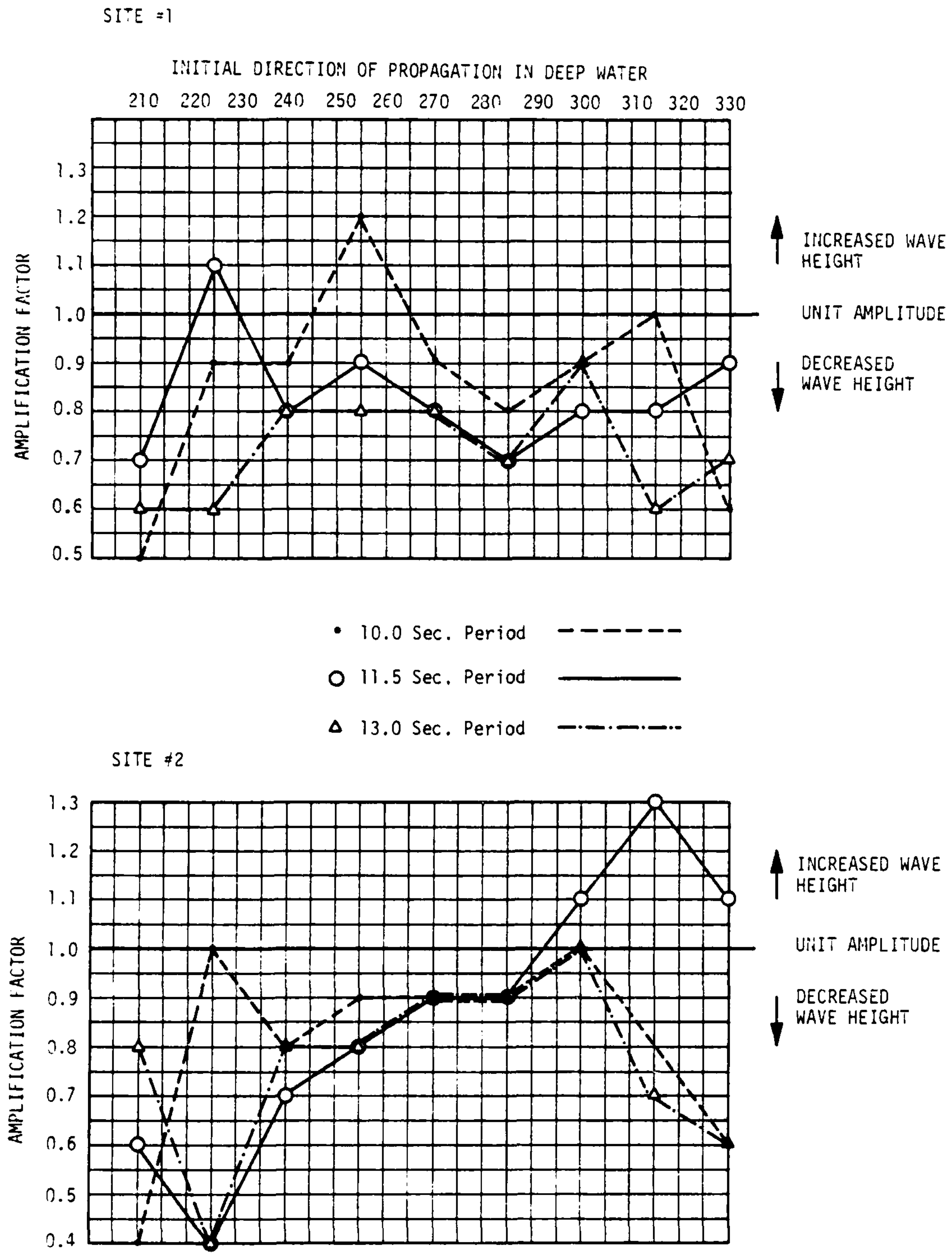


Figure 5-5. Amplification Factors at Sites #1 and #2

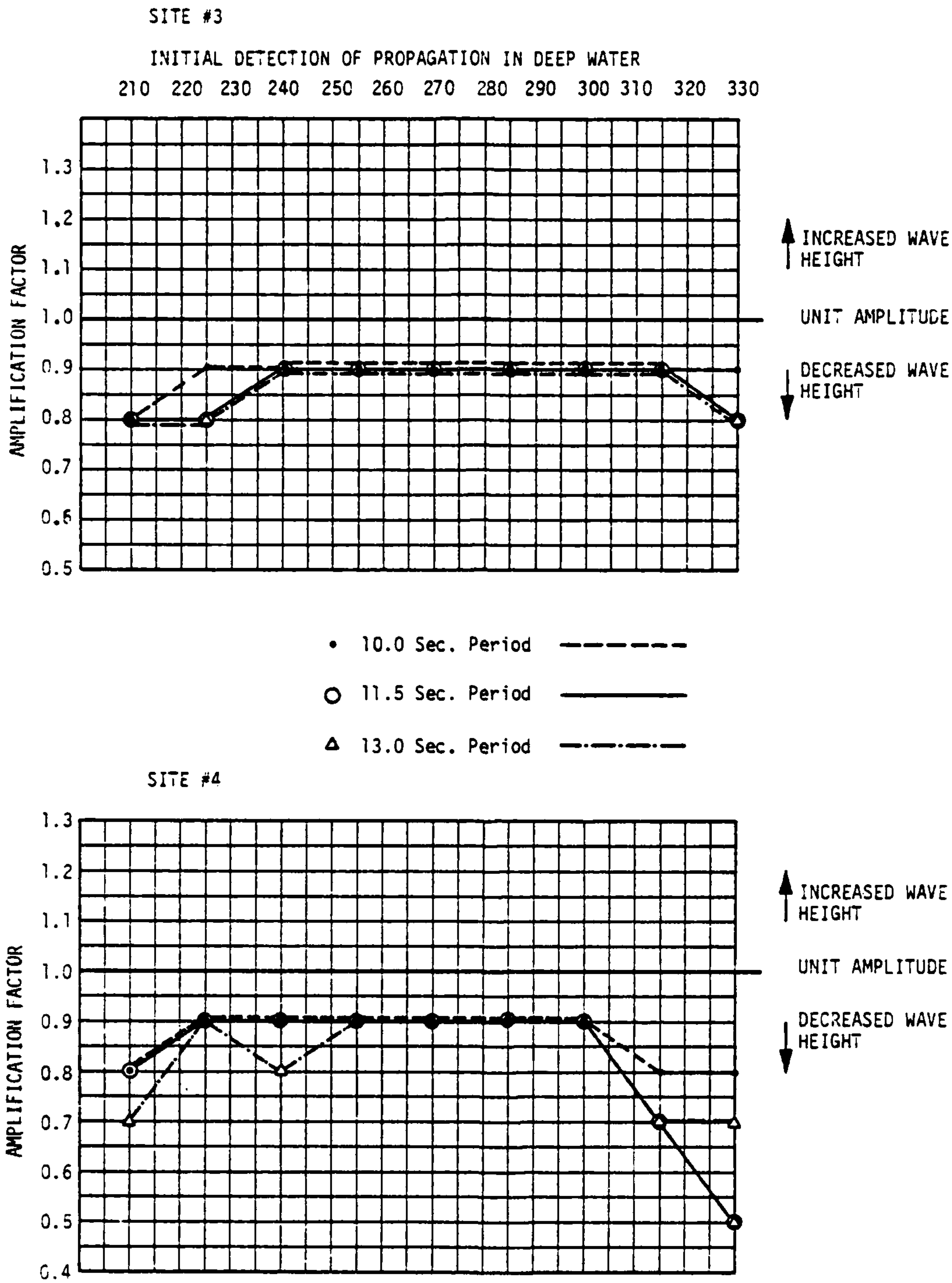


Figure 5-6. Amplification Factors at Sites #3 and #4

A geographic presentation of the amplification factors and refraction directions is given in Figures 5-7 through 5-31. The overall matrix represents a 5 x 5 section of the model grid centered on the grid point which contains a particular site. Each grid point in the Y and X directions is separated by 0.5 minute of latitude and longitude, respectively. The elements of the 5 by 5 geographic matrix are then broken down into 3 by 3 matrices. The 3 by 3 matrix gives the amplification or refracted direction data as a function of the initial direction of propagation in deep water. A key to the 3 by 3 sub-elements is given in Figure 5-7. The direction information is in degrees where negative is left or counterclockwise; thus, a -6 for an initial direction of 210° would give a direction of 204° at the grid point of concern.

It is expected that the geographic distribution of the refraction data will be useful if any relocation of the structures is contemplated. When using the data, one should assess all periods -- 10.0, 11.5, and 13.0 seconds -- before deciding on a preferred direction.

210°	225°	240°
255°	270°	285°
300°	315°	330°

*KEY TO DIRECTION OF INITIAL PROPAGATION IN DEEP WATER

Figure 5-7. Key to 3 by 3 Sub-elements*

.5	1.0	.9	.5	1.0	.9	.5	.9	.9	.5	.8	.9	.6	.7	.9
1.1	.9	.9	1.1	.9	.9	1.1	.9	.9	1.1	.9	.9	1.0	.8	.9
1.0	.7	.7	1.0	.8	.7	1.0	.9	.7	1.0	1.0	.6	.9	1.0	.6
.5	.9	.9	.5	.8	.9	.5	.7	.8	.7	.6	.8	.7	.5	.8
1.0	.9	.8	1.0	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9	.9
.9	.6	.7	.9	.6	.7	1.0	.7	.7	1.0	.8	.6	1.0	.9	.7
.5	.7	.8	.6	.6	.8	.6	.6	.8	.6	.5	.8	.6	.5	.8
.8	.8	.7	.8	.8	.7	.8	.8	.7	.8	.8	.7	.8	.8	.7
1.0	.6	.7	.9	.6	.7	.9	.6	.7	.9	.6	.8	.9	.7	.7
.6	.6	.8	.6	.6	.9	.6	.5	.9	.6	1.0	1.0	.6	1.1	1.0
.7	.8	.8	.7	.8	.8	.7	.8	.7	.7	.8	.7	.7	.8	.7
1.0	1.0	.7	1.0	.9	.7	1.0	.6	.7	.9	.6	.7	.9	.6	.8
.6	.5	1.0	.6	1.0	1.0	.6	1.1	1.0	.6	1.1	1.1	.5	1.1	1.1
.7	1.0	1.5	.7	.9	1.4	.7	.9	1.3	.7	.9	1.2	.7	.9	1.0
.9	1.0	.6	.9	1.0	.6	.9	1.0	.7	.9	.9	.7	.9	.6	.7

0.5 MINUTE LATITUDE

0.5 MINUTE LONGITUDE

WAVE HEIGHT AMPLIFICATION

SITE NO.: 1 LATITUDE: 35° 56.99'N

WAVE PERIOD: 13.0 Sec LONGITUDE: 75° 16.00'W

Figure 5-8. Amplitude Coefficients as a Function of Direction (Site #1, 13.0 Sec)

22	13	7	23	12	7	23	13	8	23	14	8	21	15	8
4	4	-3	4	4	-3	5	4	-2	6	4	-1	6	4	-1
-8	-13	-22	-8	-13	-23	-8	-13	-23	-8	-13	-23	-8	-12	-23
22	13	7	23	14	7	23	15	7	20	15	7	19	16	6
8	4	-3	8	4	-3	9	4	-2	9	4	-1	9	4	-1
-7	-13	-21	-7	-13	-21	-7	-13	-21	-7	-12	-22	-7	-12	-22
22	15	9	22	16	8	21	16	8	20	16	7	19	16	7
10	4	-3	10	4	-4	10	3	-4	9	3	-4	9	3	-4
-5	-13	-19	-6	-13	-20	-6	-12	-20	-6	-12	-20	-6	-12	-21
22	16	11	22	17	10	21	17	10	20	13	11	19	11	11
12	4	-3	11	3	-4	10	2	-4	9	2	-4	9	2	-4
-5	-11	-18	-6	-12	-19	-6	-12	-19	-6	-12	-19	-6	-12	-19
22	17	14	22	13	13	21	12	12	20	12	11	19	11	11
12	4	-1	11	3	-2	10	3	-3	9	2	-4	9	2	-4
-4	-12	-17	-6	-12	-18	-6	-13	-18	-7	-14	-19	-7	-12	-19

0.5 MINUTE LATITUDE

0.5 MINUTE LONGITUDE

DIRECTIONAL DEVIATION

SITE NO.: 1

LATITUDE: 35° 56.99'N

WAVE PERIOD: 13.0 Sec

LONGITUDE: 75° 16.00'W

Figure 5-9. Directional Deviation from Initial Propagation (Site #1, 13.0 Sec)

.5	.5	.9	.7	.7	.9	.7	.9	.9	.7	1.0	.9	.7	1.0	.8
1.2	.8	.8	1.2	.8	.8	1.2	.8	.8	1.1	.8	.8	1.1	.8	.8
1.2	.5	1.0	1.2	.5	1.0	1.2	.5	1.0	1.2	.6	.9	1.1	.8	.9
.7	.9	.9	.7	1.0	.9	.7	1.0	.8	.7	1.1	.8	.7	1.2	.8
1.1	.9	.7	1.1	.8	.7	1.1	.8	.7	1.0	.8	.8	1.0	.8	.8
.9	.8	.6	.9	.6	1.0	1.0	.5	1.0	1.1	.5	1.0	1.1	.5	1.0
.7	1.0	.8	.7	1.0	.8	.7	1.1	.8	.7	1.2	.8	.7	1.3	.8
1.0	.8	.7	.9	.8	.7	.9	.8	.7	.9	.8	.7	.9	.8	.7
.9	1.3	.5	.9	1.1	.5	.8	.8	.9	.9	.6	1.1	.9	.6	1.0
.7	1.1	.8	.7	1.2	.8	.7	1.3	.8	.7	1.4	.8	.7	1.4	.9
.9	.8	.9	.9	.8	.8	.9	.8	.8	.9	.8	.7	.8	.8	.7
.9	1.2	.5	.9	1.2	.5	.9	1.2	.5	.9	1.0	.8	.8	.7	1.1
.7	1.4	.8	.7	1.4	.9	.7	1.4	.9	.7	1.4	.9	.7	.9	1.0
.7	.8	1.0	.7	.8	1.0	.7	.8	1.0	.7	.8	1.0	.7	.8	1.0
.9	1.0	.5	.9	1.1	.5	.9	1.2	.5	.9	1.2	.5	.9	1.1	.6

0.5 MINUTE LATITUDE

0.5 MINUTE LONGITUDE

WAVE HEIGHT AMPLIFICATION

SITE NO.: 1 LATITUDE: 35° 56.99'N

WAVE PERIOD: 11.5 Sec LONGITUDE: 75° 16.00'W

Figure 5-10. Amplitude Coefficients as a Function of Direction (Site #1, 11.5 Sec)

15	9	5	18	10	5	17	12	5	17	12	5	16	10	5
2	2	-3	3	2	-2	3	3	-2	3	3	-1	4	3	-0
-7	-12	-16	-7	-12	-16	-6	-11	-15	-6	-11	-15	-5	-8	-14
18	12	5	18	13	5	17	12	6	16	11	5	15	9	5
4	3	-3	5	3	-3	5	3	-3	6	3	-2	6	3	-1
-6	-11	-14	-6	-11	-15	-6	-11	-15	-5	-11	-14	-5	-11	-14
18	14	6	17	12	6	17	10	6	16	8	6	15	6	5
7	4	-3	8	3	-3	8	3	-3	8	3	-3	7	3	-3
-5	-9	-15	-5	-10	-15	-5	-11	-15	-5	-11	-14	-5	-10	-14
18	12	7	17	10	6	16	8	6	16	6	5	15	5	4
8	4	-2	8	3	-3	8	2	-3	8	1	-3	7	1	-3
-3	-8	-15	-4	-9	-15	-4	-9	-16	-5	-10	-15	-5	-10	-13
18	10	7	17	8	6	17	7	6	16	6	6	16	7	6
9	4	-0	8	3	-1	7	2	-2	7	1	-3	7	1	-3
-3	-7	-15	-3	-8	-16	-4	-9	-16	-4	-9	-16	-4	-9	-16

0.5 MINUTE LATITUDE

0.5 MINUTE LONGITUDE

DIRECTIONAL DEVIATION

SITE NO.: 1

LATITUDE: 35° 56.99'N

WAVE PERIOD: 11.5 Sec

LONGITUDE: 75° 16.00'W

Figure 5-11. Directional Deviation from Initial Propagation (Site #1, 11.5 Sec)

1.3	.6	.7	1.0	.6	.8	.6	.6	.8	.6	.6	.8	.6	.7	.9
1.2	.9	.8	1.2	.9	.8	1.2	.9	.8	1.1	.9	.8	1.1	.9	.9
.8	1.1	.6	.8	1.0	.6	.9	.9	.6	1.1	.8	.6	1.1	.7	.6
1.2	.6	.8	.8	.6	.8	.5	.7	.9	.5	.8	.9	.6	.8	.9
1.2	.9	.8	1.2	.9	.8	1.2	.9	.8	1.2	.9	.8	1.2	.9	.8
.9	1.0	.8	.9	1.1	.6	.8	1.0	.6	.8	1.0	.6	.9	.8	.6
.9	.7	.9	.5	.8	.9	.5	.9	.9	.6	.9	.9	.8	1.0	.9
1.2	.9	.8	1.2	.9	.8	1.2	.9	.8	1.1	.9	.8	1.1	.9	.8
1.0	.8	.8	1.0	1.0	.8	.9	1.0	.6	.9	1.0	.6	.8	1.0	.6
.5	.9	.9	.5	.9	.9	.6	1.0	.9	.8	1.0	.9	1.0	1.1	.9
1.0	.9	1.2	.9	.9	1.1	.9	.9	1.1	.9	.9	1.0	.9	.9	.9
.9	.7	.8	.9	.7	.8	1.0	.9	.8	1.0	1.0	.6	.9	1.0	.6
.5	1.0	.9	.6	1.0	.9	.8	1.1	.9	1.0	1.0	.9	.9	.9	.9
.9	.9	1.1	.9	.9	1.1	.9	.9	1.1	.9	.9	1.1	.8	.9	1.1
.8	.7	.8	.8	.7	.8	.8	.7	.8	.9	.8	.8	1.0	1.0	.6

0.5 MINUTE LATITUDE

0.5 MINUTE LONGITUDE

WAVE HEIGHT AMPLIFICATION

SITE NO.: 1

LATITUDE: 35° 56.99'N

WAVE PERIOD: 10.0 Sec

LONGITUDE: 75° 16.00'W

Figure 5-12. Amplitude Coefficients as a Function of Direction (Site #1, 10.0 Sec)

8	7	3	9	7	3	10	7	3	9	6	3	9	4	2
2	1	-2	2	1	-1	2	1	-1	2	1	-0	2	2	-0
-3	-6	-14	-3	-7	-13	-3	-7	-13	-3	-7	-13	-3	-7	-12
8	7	3	10	7	4	10	6	3	10	5	3	9	4	2
3	2	-1	3	2	-1	3	2	-1	3	2	-1	3	2	-1
-3	-6	-12	-3	-6	-13	-3	-6	-13	-2	-6	-12	-2	-7	-12
10	7	4	11	6	4	11	6	4	10	6	3	9	6	3
4	3	-1	5	2	-1	5	2	-1	5	2	-1	5	2	-1
-3	-4	-12	-3	-5	-12	-2	-5	-12	-2	-5	-12	-2	-6	-12
13	8	5	12	7	4	11	7	4	10	6	3	8	6	3
7	3	-0	7	2	-1	6	1	-1	6	1	-2	6	1	-2
-1	-4	-12	-2	-4	-12	-2	-5	-12	-2	-4	-12	-2	-5	-11
14	9	6	13	8	5	11	7	4	9	6	3	9	6	3
8	3	0	7	2	-0	6	1	-1	6	1	-1	5	1	-2
-1	-4	-12	-2	-4	-12	-2	-5	-12	-2	-5	-12	-2	-4	-12

0.5 MINUTE LATITUDE

0.5 MINUTE LONGITUDE

DIRECTIONAL DEVIATION

SITE NO.: 1

LATITUDE: 35° 56.99'N

WAVE PERIOD: 10.0 Sec

LONGITUDE: 75° 16.00'W

Figure 5-13. Directional Deviation from Initial Propagation (Site #1, 10.0 Sec)

.7	.4	.7	.7	.4	.8	.7	.4	.8	.7	.4	.8	.7	.4	.8
1.0	1.0	.9	1.0	.9	.9	1.0	.9	.9	.9	.9	.9	.9	.9	.8
.9	1.1	.5	.9	1.1	.5	.9	1.1	.6	.9	1.1	.6	.9	1.1	.7
.7	.4	.8	.7	.4	.8	.7	.4	.8	.8	.4	.8	.8	.4	.8
.9	.9	.9	.9	.9	.9	.9	.9	.9	.8	.9	.9	.8	.9	.9
.9	.8	.5	.9	.7	.5	.9	1.1	.6	.9	1.1	.6	.9	1.1	.6
.8	.4	.8	.8	.4	.8	.8	.4	.8	.8	.4	.7	.8	.4	.7
.9	.9	.9	.9	.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9
1.0	.9	.6	1.0	.8	.6	1.0	.7	.6	.9	.6	.6	.9	1.1	.6
.8	.4	.8	.8	.4	.7	.8	.4	.7	.8	.4	.7	.7	.4	.7
.8	1.0	.9	.7	1.0	.9	.7	1.0	.9	.7	1.1	.9	.7	1.1	.9
1.1	.9	.8	1.1	.9	.7	1.1	.8	.6	1.1	.8	.6	1.0	.7	.6
.8	.4	.6	.8	.4	.7	.7	.4	.7	.7	.4	.7	.7	.4	.7
.8	1.1	1.3	.7	1.1	1.2	.7	1.1	1.1	.7	1.1	1.0	.8	1.1	1.0
1.1	.9	.9	1.1	.9	.9	1.1	.9	.8	1.1	.8	.6	1.1	.8	.6

0.5 MINUTE LATITUDE

0.5 MINUTE LONGITUDE

WAVE HEIGHT AMPLIFICATION

SITE NO.: 2　　LATITUDE: 36° 13.60'N

WAVE PERIOD: 13.0 Sec　　LONGITUDE: 75° 14.99'W

Figure 5-14. Amplitude Coefficients as a Function of Direction (Site #2, 13.0 Sec)

23	19	8	24	19	8	25	19	8	25	19	8	24	20	8
1	-3	-4	1	-3	-5	2	-3	-5	2	-3	-5	2	-3	-5
-8	-14	-23	-8	-14	-22	-8	-14	-18	-8	-13	-17	-8	-12	-16
25	19	8	25	19	8	25	19	8	24	20	8	23	21	8
2	-3	-3	2	-3	-3	2	-3	-3	2	-2	-3	2	-2	-3
-7	-15	-23	-7	-15	-23	-7	-12	-23	-7	-12	-20	-7	-12	-17
26	20	8	25	20	8	24	21	8	22	21	8	20	21	8
2	-2	-4	2	-2	-4	2	-2	-4	2	-2	-3	2	-2	-3
-6	-14	-23	-6	-15	-23	-6	-15	-23	-7	-16	-23	-7	-11	-22
25	21	8	22	21	8	20	20	8	19	20	8	19	19	8
2	-1	-4	1	-1	-4	1	-2	-4	1	-2	-4	1	-2	-4
-7	-15	-22	-6	-15	-22	-6	-15	-22	-6	-15	-23	-6	-16	-23
20	20	8	18	19	8	18	18	8	18	18	8	17	18	8
1	-1	-4	1	-1	-5	1	-1	-5	1	-1	-4	1	-1	-4
-8	-14	-22	-8	-15	-22	-7	-15	-22	-7	-15	-23	-6	-15	-23

0.5 MINUTE LATITUDE

0.5 MINUTE LONGITUDE

DIRECTIONAL DEVIATION

SITE NO.: 2

LATITUDE: 36° 13.60'N

WAVE PERIOD: 13.0 Sec

LONGITUDE: 75° 14.99'W

Figure 5-15. Directional Deviation from Initial Propagation (Site #2, 13.0 Sec)

.4	.7	.7	.4	.5	.7	.4	.5	.7	.4	.5	.7	.6	.5	.7
1.0	.9	.9	1.0	.9	.9	1.0	.9	.9	.9	.9	.9	.9	.9	.9
.9	1.4	1.0	.9	.7	.6	.9	.5	.4	.9	.5	.4	.9	.5	.5
.4	.5	.7	.4	.5	.7	.5	.5	.7	.6	.4	.7	.6	.4	.7
.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9
1.1	1.3	1.1	1.0	1.4	1.1	1.0	1.3	.7	.9	.6	.5	.9	.5	.5
.5	.5	.7	.5	.4	.7	.6	.4	.7	.6	.4	.7	.6	.4	.8
.9	.9	.8	.8	.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9
1.1	1.2	1.0	1.1	1.3	1.0	1.1	1.3	1.1	1.1	1.3	.9	1.0	1.1	.5
.6	.4	.7	.6	.4	.7	.6	.4	.8	.6	.4	.8	.6	.4	.8
.8	1.0	.9	.8	1.0	.9	.8	1.0	.9	.8	1.0	.9	.8	1.0	.9
.9	1.0	.9	1.0	1.1	1.0	1.1	1.2	1.0	1.1	1.2	1.0	1.1	1.3	1.0
.6	.4	.7	.7	.4	.8	.6	.4	.8	.5	.4	.8	.5	.4	.8
.8	1.1	1.2	.8	1.1	1.2	.8	1.1	1.1	.8	1.1	1.0	.8	1.0	1.0
.5	.9	.6	.6	.9	.8	.8	1.0	.9	1.0	1.1	1.0	1.1	1.2	1.0

0.5 MINUTE LATITUDE

0.5 MINUTE LONGITUDE

WAVE HEIGHT AMPLIFICATION

SITE NO.: 2

LATITUDE: 36° 13.60'N

WAVE PERIOD: 11.5 Sec

LONGITUDE: 75° 14.99'W

Figure 5-16. Amplitude Coefficients as a Function of Direction (Site #2, 11.5 Sec)

14	18	5	14	18	5	15	17	5	17	17	5	20	17	5
0	-3	-3	0	-3	-3	0	-3	-3	0	-3	-4	0	-2	-4
-5	-12	-19	-5	-7	-18	-5	-6	-17	-6	-6	-17	-6	-6	-17
15	17	5	16	17	5	18	17	5	22	18	6	24	18	6
0	-2	-2	1	-2	-2	1	-2	-2	2	-2	-2	2	-2	-2
-5	-12	-18	-5	-13	-19	-5	-12	-18	-5	-6	-17	-5	-6	-17
17	17	6	20	18	6	23	18	7	24	18	8	25	18	8
2	-1	-3	2	-1	-3	2	-1	-3	2	-1	-3	2	-1	-3
-5	-12	-18	-5	-12	-18	-5	-12	-19	-5	-13	-18	-5	-11	-17
21	18	8	23	18	8	24	18	8	25	17	8	22	17	8
2	-1	-3	2	-1	-3	2	-1	-3	1	-1	-3	1	-1	-3
-4	-11	-17	-5	-12	-18	-5	-12	-18	-5	-12	-19	-5	-13	-19
23	18	8	25	17	8	24	17	8	19	17	7	18	17	5
0	-1	-4	0	-1	-4	0	-1	-4	0	-1	-4	0	-1	-4
-3	-11	-17	-3	-11	-17	-3	-11	-17	-4	-12	-18	-4	-12	-18

0.5 MINUTE LATITUDE

0.5 MINUTE LONGITUDE

DIRECTIONAL DEVIATION

SITE NO.: 2

LATITUDE: 36° 13.60'N

WAVE PERIOD: 11.5 Sec

LONGITUDE: 75° 14.99'W

Figure 5-17. Directional Deviation from Initial Propagation (Site #2, 11.5 Sec)

.3	1.0	.6	.3	.10	.6	.3	1.0	.6	.4	1.0	.6	.4	1.0	.6
.9	.9	1.0	.9	.9	1.0	.9	.9	1.0	.9	.9	.9	.9	.9	.9
1.0	.8	.7	.9	.8	.8	.9	.8	.8	.9	.8	.8	.9	.8	.8
.3	1.0	.6	.3	1.0	.6	.4	1.0	.7	.4	1.0	.7	.3	1.0	.8
.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9
1.0	.8	.6	1.0	.8	.6	1.0	.8	.7	.9	.8	.8	.9	.8	.8
.3	1.0	.7	.4	1.0	.8	.4	1.0	.8	.3	1.0	.8	.3	.9	.8
.9	.9	.8	.9	.9	.8	.9	.9	.9	.9	.9	.9	.9	.9	.9
.9	.7	.6	1.0	.8	.6	1.0	.8	.6	1.0	.9	.7	1.0	.8	.8
.4	1.0	.8	.4	1.0	.8	.3	.9	.8	.3	.9	.8	.3	.8	.8
.9	1.1	.9	.9	1.1	.9	.9	1.1	.9	.9	1.1	.9	.9	1.1	.9
.7	.7	.7	.7	.7	.7	.9	.7	.6	1.0	.8	.6	1.0	.9	.7
.4	1.0	.8	.3	.9	.8	.3	.8	.8	.3	.8	.8	.3	.7	.8
.9	1.2	1.1	.9	1.2	1.1	.9	1.1	1.0	.9	1.1	1.0	.9	1.1	1.0
.6	.9	.7	.6	.7	.7	.7	.7	.7	.7	.7	.6	.8	.7	.6

0.5 MINUTE LATITUDE

0.5 MINUTE LONGITUDE

WAVE HEIGHT AMPLIFICATION

SITE NO.: 2

LATITUDE: 36° 13.60'N

WAVE PERIOD: 10.0 Sec

LONGITUDE: 75° 14.99'W

Figure 5-18. Directional Deviation from Initial Propagation (Site #2, 10.0 Sec)

13	9	4	13	8	4	12	7	4	11	6	4	11	6	4
0	-2	-1	0	-2	-1	0	-2	-1	0	-2	-2	0	-2	-2
-3	-8	-12	-4	-8	-13	-4	-7	-14	-4	-7	-14	-4	-7	-14
13	7	4	11	6	4	11	6	4	11	7	5	11	11	5
0	-1	-2	0	-1	-2	0	-1	-1	0	-1	-1	0	-1	-1
-3	-8	-12	-3	-8	-12	-3	-8	-13	-3	-7	-13	-4	-7	-14
11	6	5	11	6	5	11	9	5	11	12	5	11	13	5
0	-0	-2	1	-0	-2	1	-0	-2	1	-0	-2	1	-0	-2
-2	-8	-8	-2	-8	-12	-3	-8	-12	-3	-8	-13	-3	-8	-13
11	8	5	11	11	5	11	13	5	11	14	5	11	14	5
1	-1	-2	1	-1	-2	1	-1	-2	1	-1	-2	1	-1	-2
-2	-8	-7	-2	-8	-8	-2	-8	-12	-2	-8	-12	-2	-8	-13
11	13	5	11	14	5	11	14	4	11	14	4	11	14	3
1	-1	-3	0	-1	-3	0	-1	-3	0	-1	-3	-0	-1	-3
-1	-9	-8	-2	-8	-8	-2	-8	-9	-2	-8	12	-2	-8	-12

0.5 MINUTE LATITUDE

0.5 MINUTE LONGITUDE

DIRECTIONAL DEVIATION

SITE NO.: 2

LATITUDE: 36° 13.60'N

WAVE PERIOD: 10.0 Sec

LONGITUDE: 75° 14.99'W

Figure 5-19. Directional Deviation from Initial Propagation (Site #2, 10.0 Sec)

.7	.7	.9	.7	.8	.9	.8	.8	.9	.8	.8	.9	.8	.8	.9
.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9
.9	.8	.8	.9	.8	.8	.9	.8	.8	.9	.9	.9	.9	.9	.9
.7	.8	.9	.8	.8	.9	.8	.8	.9	.8	.8	.9	.8	.8	.9
.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9
.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9	.9
.8	.9	.9	.8	.8	.9	.8	.8	.9	.7	.8	.9	.7	.8	.9
.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9
.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9	.8
.8	.8	.9	.8	.8	.9	.7	.8	.9	.7	.8	.9	.7	.8	.9
.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9
.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9	.8
.7	.8	.9	.7	.8	.9	.7	.8	.9	.7	.8	.9	.7	.8	.9
.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9
.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9	.8

0.5 MINUTE LATITUDE

0.5 MINUTE LONGITUDE

WAVE HEIGHT AMPLIFICATION

SITE NO.: 3 LATITUDE: 36° 03.87'N

WAVE PERIOD: 13.0 Sec LONGITUDE: 74° 59.00'W

Figure 5-20. Amplitude Coefficients as a Function of Direction (Site #3, 13.0 Sec)

18	12	6	18	12	6	18	11	7	17	11	7	16	10	6
3	0	-1	4	1	-1	4	1	-0	4	2	-0	4	2	-0
-5	-10	-12	-4	-9	-13	-3	-7	-12	-2	-5	-12	-2	-4	-11
17	11	6	18	11	6	17	11	7	17	11	7	16	10	7
3	0	-2	4	1	-1	4	1	-1	4	1	-0	4	1	-0
-6	-9	-11	-6	-9	-12	-5	-9	-12	-3	-7	-12	-2	-5	-12
17	10	7	17	11	8	18	12	8	18	12	8	17	10	7
4	0	-2	4	0	-2	4	1	-1	4	1	-1	3	1	-0
-5	-8	-10	-5	-8	-11	-5	-8	-12	-4	-7	-12	-3	-6	-12
17	11	8	18	13	8	19	13	8	19	11	7	15	9	6
4	0	-2	4	0	-2	4	1	-1	4	1	-1	3	1	-0
-5	-8	-9	-5	-8	-10	-5	-8	-11	-4	-7	-11	-3	-6	-12
19	13	7	20	13	7	20	12	7	16	10	6	14	9	6
3	0	-2	3	0	-2	3	0	-2	3	1	-1	2	1	-1
-4	-8	-9	-5	-8	-9	-4	-8	-10	-4	-7	-11	-3	-6	-11

0.5 MINUTE LATITUDE

0.5 MINUTE LONGITUDE

DIRECTIONAL DEVIATION

SITE NO.: 3

LATITUDE: 36° 03.87'N

WAVE PERIOD: 13.0 Sec

LONGITUDE: 74° 59.00'W

Figure 5-21. Directional Deviation from Initial Propagation (Site #3, 13.0 Sec)

.8	.8	.9	.8	.8	.9	.8	.8	.9	.8	.8	.9	.8	.8	.9
.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9
.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9	.9
.8	.8	.9	.8	.8	.9	.8	.8	.9	.8	.8	.9	.8	.9	.9
.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9
.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9	.9
.8	.8	.9	.8	.8	.9	.8	.8	.9	.8	.8	.9	.8	.9	.9
.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9
.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9	.9
.8	.9	.9	.8	.9	.9	.7	.8	.9	.8	.9	.9	.8	.9	.9
.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9
.9	.9	.9	.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9	.9
.8	.9	.9	.7	.8	.9	.7	.8	.9	.8	.9	.9	.8	.9	.9
.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9
.9	.9	.9	.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9	.9

0.5 MINUTE LATITUDE

0.5 MINUTE LONGITUDE

WAVE HEIGHT AMPLIFICATION

SITE NO.: 3

LATITUDE: 36° 03.87'N

WAVE PERIOD: 11.5 Sec

LONGITUDE: 74° 59.00'W

Figure 5-22. Amplitude Coefficients as a Function of Direction (Site #3, 11.5 Sec)

13	8	5	13	7	5	13	8	5	12	8	5	11	7	4
2	0	-1	2	1	-0	3	1	-0	3	1	0	3	1	0
-4	-6	-10	-3	-6	-10	-2	-6	-8	-1	-4	-6	-1	-2	-5
12	7	4	12	7	4	13	8	5	12	8	5	11	7	4
2	0	-1	2	0	-1	3	1	-0	3	1	-0	3	1	0
-4	-6	-9	-4	-6	-10	-3	-5	-9	-2	-4	-7	-1	-3	-5
12	7	4	12	8	5	13	9	5	13	8	5	12	6	4
2	0	-1	3	0	-1	3	0	-1	2	1	-0	2	1	-0
-3	-6	-9	-3	-6	-9	-3	-6	-9	-2	-4	-7	-1	-3	-6
12	8	5	13	8	6	14	8	6	13	7	5	10	6	4
3	0	-1	3	0	-1	3	0	-1	2	0	-0	2	0	-0
-3	-6	-8	-3	-6	-9	-3	-5	-9	-2	-5	-7	-1	-3	-6
13	8	5	15	9	5	15	8	5	12	7	4	9	5	3
2	0	-1	2	0	-1	2	0	-1	2	0	-1	2	0	-0
-3	-5	-8	-3	-5	-8	-3	-5	-8	-2	-4	-7	-2	-3	-6

0.5 MINUTE LATITUDE

0.5 MINUTE LONGITUDE

DIRECTIONAL DEVIATION

SITE NO.: 3

LATITUDE: 36° 03.87'N

WAVE PERIOD: 11.5 Sec

LONGITUDE: 74° 59.00'W

Figure 5-23. Directional Deviation from Initial Propagation (Site #3, 11.5 Sec)

7	5	2	7	5	2	7	4	2	7	4	3	7	3	2
1	0	-0	1	0	-0	1	0	0	1	1	0	1	1	0
-2	-3	-5	-2	-3	-5	-1	-2	-5	-0	-1	-3	-0	-1	-2
7	4	2	7	4	2	8	4	3	7	4	3	6	4	2
1	0	-0	1	0	-0	1	0	-0	1	0	0	1	0	0
-2	-3	-5	-2	-3	-5	-1	-3	-5	-1	-2	-4	-0	-1	-2
7	3	2	7	4	2	8	5	3	8	5	2	6	3	2
1	0	-1	1	0	-0	1	0	-0	1	0	-0	1	0	-0
-1	-3	-5	-1	-3	-5	-1	-3	-5	-1	-2	-4	-0	-1	-2
7	4	3	8	5	3	9	5	3	8	4	2	5	3	2
1	0	-0	1	0	-0	1	0	-0	1	0	-0	1	0	-0
-1	-3	-5	-1	-3	-5	-1	-3	-5	-1	-2	-4	0	-1	-2
8	5	3	9	5	3	9	4	3	7	4	2	5	3	1
1	0	-0	1	0	-0	1	0	-0	1	0	-0	1	0	-0
-1	-2	-4	-1	-3	-5	-1	-3	-5	-1	-2	-3	-0	-1	-2

0.5 MINUTE LATITUDE

0.5 MINUTE LONGITUDE

DIRECTIONAL DEVIATION

SITE NO.: 3

LATITUDE: 36° 03.87'N

WAVE PERIOD: 10.0 Sec

LONGITUDE: 74° 59.00'W

Figure 5-24. Directional Deviation from Initial Propagation (Site #3, 10.0 Sec)

.8	.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9
.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9
.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9
.8	.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9
.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9
.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9
.8	.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9
.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9
.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9
.8	.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9
.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9
.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9
.8	.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9
.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9
.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9

0.5 MINUTE LATITUDE

0.5 MINUTE LONGITUDE

WAVE HEIGHT AMPLIFICATION

SITE NO.: 3 LATITUDE: 36° 03.87'N

WAVE PERIOD: 10.0 Sec LONGITUDE: 74° 59.00'W

Figure 5-25. Amplitude Coefficients as a Function of Direction (Site #3, 10.0 Sec)

.5	.9	.9	.7	.9	.9	.7	.9	.8	.7	.9	.8	.7	.9	.8
.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9	.8
.9	.8	.7	.9	.9	.7	.9	1.0	.7	.9	1.1	.7	.9	1.1	.8
.7	.9	.8	.7	.9	.8	.7	.9	.8	.7	.9	.8	.7	.9	.8
.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9	.8
.9	.7	.6	.9	.8	.7	.9	.8	.7	.9	.9	.7	.9	1.0	.7
.7	.9	.8	.7	.9	.8	.7	.9	.8	.7	.9	.8	.8	1.0	.8
.9	.9	1.0	.9	.9	1.0	.9	.9	.9	.9	.9	.9	.9	.9	.9
.9	.6	.5	.9	.7	.6	.9	.7	.7	.9	.8	.7	.9	.8	.7
.7	.9	.8	.7	.9	.8	.7	1.0	.8	.8	1.0	.8	.9	1.0	.8
.9	.9	1.0	.9	.9	1.0	.9	.9	1.0	.9	.9	1.0	.9	.9	1.0
.8	.6	.4	.8	.6	.4	.8	.6	.5	.9	.7	.7	.9	.7	.7
.7	1.0	.8	.8	1.0	.8	.9	1.0	.8	.9	1.0	.8	.9	1.0	.9
.9	.8	1.0	.9	.8	1.0	.9	.8	1.0	.9	.8	1.0	.9	.8	1.0
.8	.6	.4	.8	.6	.4	.8	.6	.4	.8	.6	.5	.8	.6	.6

0.5 MINUTE LATITUDE

0.5 MINUTE LONGITUDE

WAVE HEIGHT AMPLIFICATION

SITE NO.: 4

LATITUDE: 35° 47.19'N

WAVE PERIOD: 13.0 Sec

LONGITUDE: 75° 05.71'W

Figure 5-26. Amplitude Coefficients as a Function of Direction (Site #4, 13.0 Sec)

21 11 9 5 1 -2 -8 -11 -21	17 11 9 5 1 -2 -8 -11 -20	16 11 9 5 1 -2 -7 -11 -18	16 12 9 5 1 -2 -7 -11 -17	16 13 9 4 1 -2 -7 -11 -17
17 12 10 5 1 -3 -7 -12 -21	17 13 10 5 1 -3 -7 -11 -21	17 13 10 5 1 -2 -7 -11 -20	17 13 9 4 0 -2 -7 -10 -18	18 13 9 4 0 -2 -7 -10 -17
19 14 10 4 1 -4 -7 -14 -20	20 14 10 4 0 -4 -7 -13 -20	20 14 9 4 0 -4 -7 -11 -20	19 14 8 3 0 -4 -7 -10 -20	18 13 7 3 0 -4 -7 -10 -19
19 15 9 4 0 -4 -7 -14 -20	20 15 8 4 0 -4 -7 -14 -19	20 14 8 4 0 -4 -7 -13 -19	19 14 8 3 0 -4 -7 -12 -20	18 13 7 3 0 -4 -7 -10 -19
21 15 9 4 -0 -4 -7 -14 -19	21 15 8 4 -0 -4 -7 -14 -19	20 14 8 3 -0 -4 -7 -13 -19	19 14 7 3 -0 -4 -7 -13 -19	17 13 7 3 -0 -4 -7 -13 -19

0.5 MINUTE LATITUDE

0.5 MINUTE LONGITUDE

DIRECTIONAL DEVIATION

SITE NO.: 4

LATITUDE: 35° 47.19'N

WAVE PERIOD: 13.0 Sec

LONGITUDE: 75° 05.71'W

Figure 5-27. Directional Deviation from Initial Propagation (Site #4, 13.0 Sec)

.6	.8	.9	.6	.9	.9	.6	.9	.9	.7	.9	.9	.8	.9	.9
.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9
.9	.7	.5	.9	.7	.5	.9	.7	.5	.9	.8	.7	.9	.9	.9
.6	.9	.9	.6	.9	.9	.7	.9	.9	.8	.9	.8	.8	.9	.8
.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9
.9	.7	.5	.9	.7	.5	.9	.7	.5	.9	.7	.5	.9	.8	.7
.6	.9	.8	.8	.9	.8	.8	.9	.8	.8	.9	.8	.7	.9	.8
.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9
.9	.7	.5	.9	.7	.5	.9	.7	.5	.9	.7	.5	.9	.7	.5
.8	.9	.8	.8	.9	.8	.7	.9	.8	.7	.9	.9	.7	.9	.9
.9	.9	1.0	.9	.9	1.0	.9	.9	.9	.9	.9	.9	.9	.9	.9
.8	.7	.5	.8	.8	.5	.9	.8	.5	.9	.7	.5	.9	.7	.5
.8	.9	.9	.7	.9	.9	.7	.8	.9	.7	.9	.9	.7	.9	.9
.9	.8	1.0	.9	.8	1.0	.9	.9	1.0	.9	.9	1.0	.9	.9	1.0
.8	.8	.5	.8	.8	.5	.8	.8	.5	.8	.8	.5	.8	.8	.6

0.5 MINUTE LATITUDE

0.5 MINUTE LONGITUDE

WAVE HEIGHT AMPLIFICATION

SITE NO.: 4 LATITUDE: 35° 47.19'N

WAVE PERIOD: 11.5 Sec LONGITUDE: 75° 05.71'W

Figure 5-28. Amplitude Coefficients as a Function of Direction (Site #4, 11.5 Sec)

14	8	7	13	8	7	13	8	7	13	9	7	13	9	6
4	1	-1	4	1	-1	3	1	-1	3	1	-1	3	1	-1
-5	-9	-16	-5	-8	-15	-5	-8	-15	-4	-7	-14	-4	-6	-12
14	8	7	14	9	7	14	9	7	14	9	6	13	9	6
4	1	-2	4	1	-2	3	1	-2	3	1	-1	3	0	-1
-4	-9	-15	-4	-8	-15	-4	-8	-15	-4	-8	-15	-4	-7	-14
14	10	7	14	10	7	14	10	7	14	10	6	13	9	6
3	1	-2	3	1	-2	3	0	-2	3	0	-2	2	0	-2
-4	-11	-16	-4	-9	-15	-4	-8	-15	-4	-8	-15	-4	-7	-14
15	11	7	15	11	7	15	11	6	14	10	6	13	9	5
3	0	-2	3	0	-2	3	0	-2	2	0	-2	2	0	-2
-5	-11	-18	-4	-11	-17	-4	-10	-15	-4	-8	-14	-3	-7	-14
15	11	7	15	11	6	15	10	6	14	9	5	13	8	5
3	0	-2	3	0	-2	3	0	-2	2	-0	-2	2	-0	-2
-6	-11	-18	-5	-11	-18	-5	-10	-18	-4	-10	-14	-4	-9	-14

0.5 MINUTE LATITUDE

0.5 MINUTE LONGITUDE

DIRECTIONAL DEVIATION

SITE NO.: 4

LATITUDE: 35° 47.19'N

WAVE PERIOD: 11.5 Sec

LONGITUDE: 75° 05.71'W

Figure 5-29. Directional Deviation from Initial Propagation (Site #4, 11.5 Sec)

13	5	3	12	5	4	9	5	4	8	5	4	8	5	4
2	1	-0	2	1	-0	2	1	-0	2	1	-0	2	0	-0
-2	-5	-11	-2	-5	-10	-2	-4	-10	-2	-3	-10	-2	-3	-9
13	5	5	9	5	5	8	5	5	8	6	4	8	6	3
2	0	-1	2	0	-0	2	0	-0	2	0	-0	2	0	-0
-2	-6	-11	-2	-5	-11	-2	-5	-10	-2	-4	-9	-2	-3	-9
10	6	5	9	6	4	9	6	4	9	6	4	9	6	3
2	0	-1	2	0	-1	2	0	-1	2	0	-0	1	0	-0
-2	-6	-11	-2	-6	-11	-1	-5	-11	-1	-5	-10	-1	-4	-9
9	7	4	9	7	4	10	7	4	9	6	3	8	5	3
2	0	-1	2	0	-1	2	0	-1	1	0	-1	1	0	-1
-2	-6	-11	-2	-6	-11	-2	-6	-11	-2	-5	-10	-1	-4	-9
10	7	4	10	7	4	10	6	3	9	6	3	8	5	3
2	0	-1	2	0	-1	2	0	-1	1	0	-1	1	0	-1
-3	-7	-11	-2	-6	-11	-2	-6	-11	-2	-5	-10	-2	-5	-10

0.5 MINUTE LATITUDE

0.5 MINUTE LONGITUDE

DIRECTIONAL DEVIATION

SITE NO.: 4

LATITUDE: 35° 47.19'N

WAVE PERIOD: 10.0 Sec

LONGITUDE: 75° 05.71'W

Figure 5-30. Directional Deviation from Initial Propagation (Site #4, 10.0 Sec)

.6	.9	1.0	.6	.9	.9	.7	.9	.9	.7	.9	.9	.8	.9	.9
.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9
.9	.8	.8	.9	.8	.7	.9	.8	.6	.9	.8	.6	.9	.8	.6
.6	.9	.9	.7	.9	.9	.7	.9	.9	.8	.9	.9	.8	.9	.9
.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9
.9	.8	.8	.9	.8	.8	.9	.8	.7	.9	.8	.6	.9	.8	.6
.7	.9	.9	.7	.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9
.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9
.9	.8	.8	.9	.8	.8	.9	.8	.8	.9	.8	.7	.9	.8	.6
.7	.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9
.9	.9	1.0	.9	.9	1.0	.9	.9	1.0	.9	.9	.9	.9	.9	.9
.8	.8	.8	.9	.8	.8	.9	.8	.8	.9	.8	.8	.9	.8	.7
.8	.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9	.8	.9	.9
.9	.9	.9	.9	.9	.9	.9	.9	1.0	.9	.9	1.0	.9	.9	1.0
.9	1.0	.8	.9	.9	.8	.9	.8	.8	.9	.8	.8	.9	.8	.8

0.5 MINUTE LATITUDE

0.5 MINUTE LONGITUDE

WAVE HEIGHT AMPLIFICATION

SITE NO.: 4

LATITUDE: 35° 47.19'N

WAVE PERIOD: 10.0 Sec

LONGITUDE: 75° 05.71'W

Figure 5-31. Amplitude Coefficients as a Function of Direction (Site #4, 10.0 Sec)

6.0 IMPACT ON ENGINEERING DESIGN

The accepted wave design criteria for the four sites are as follows:

Site #	50 Yr Storm Wave Ht (Ft)	Period (Sec)
1	60.3	13.6
2	60.8	13.6
3	61.3	13.6
4	61.3	13.6

Extrapolations were made of the wave climate data to derive a data base for fatigue analysis. It is noteworthy that wave refraction renders these appraisals more conservative in the case of sites #3 and #4. This is mainly due to the fact that the wave amplification factor for sites #3 and #4 remains less than unity for all periods and directions considered.

For sites #1 and #2 the picture is not as clear. In the case of site #1, amplification is expected for 10.0-second and 11.5-second waves propagating toward the site from the northeast. This evidence indicates that the fatigue analysis data for this site should be biased somewhat upward (probably less than 1%). In the case of site #2, strong amplification is indicated for the 11.5-second waves coming from the southeast. Particular consideration should be given to the fatigue impact for this case because amplification occurs for all southeast directions considered. (This effect is probably less than 2%.)

DTIC

FILMED

4-86

END